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15 December 1969

Materiel Test Procedure 6-2-185
Electronic Proving GroundU. S. ARMY TEST AND EVALUATION COMMAND
COMMODITY ENGINEERING TEST PROCEDURE

METEOROLOGICAL SOUNDING SYSTEMS

1. OBJECTIVE

The objective of this materiel test procedure is to describe the engineering tests required to determine the technical performance of Meteorological Sounding Systems relative to criteria contained in applicable Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR), Technical Characteristics (TC), and other appropriate technical specifications.

2. BACKGROUND

The primary purpose of Meteorological Sounding Systems is to determine meteorological conditions at a given time. A present meteorological sounding system utilizes a balloon borne radiosonde consisting of a transmitter and meteorological measuring elements which sends temperature, humidity and pressure signals to a ground receiver and recorder system. Upper atmosphere wind speed and direction may be obtained from the position and horizontal movement of the sounding element (radiosonde). These signals are then reduced to meaningful data by the ground operator.

More sophisticated systems include use of rockets to carry a radiosonde to a specific altitude or use of a ground computer to reduce the telemetered radio signals to meaningful data in a very short time. These systems vary to some extent depending on their use and the degree of accuracy desired.

To ensure that the sounding systems meet applicable military and technical requirements, it is necessary to subject them to the appropriate engineering tests.

3. REQUIRED EQUIPMENT

- a. Power meter
- b. Frequency counter
- c. Oscilloscope
- d. Voltmeter
- e. Spectrum analyzer
- f. Signal generator
- g. Temperature, humidity, and pressure chamber
- h. Theodolite or surveyors transit
- i. Dummy load
- j. Signal sampler
- k. Attenuator
- l. Frequency counter
- m. Noise and field intensity meter (NFIM)
- n. Distortion analyzer

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4. REFERENCES

- A. Evaluation of Semi-automatic and Automatic Sounding Equipments, U. S. Army Signal Research and Development Lab., Fort Monmouth, New Jersey, July 1962
- B. Automatic Atmospheric Sounding Set, AN/TMQ-19 (XE-1), Sept. 1967
- C. New Meteorological Sensors, Stanford Research Institute, September 1962
- D. Manual for Radiosonde Observations (WBAN), U. S. Weather Bureau, June 1957
- E. TM 11-6660-228-10, Radiosonde AN/AMT-4C and 4D
- F. MIL-STD-810B, Environmental Test Methods
- G. MIL-STD-462, Electromagnetic Interference Characteristics, Measurement of
- H. MIL-STD-449, Measurement of Radio Frequency Spectrum Characteristics
- I. MTP 3-1-002, Confidence Intervals and Sample Size
- J. MTP 5-2-532, Computers (Electronic)
- K. MTP 6-2-020, Radar Antenna, Subsystem Tests
- L. MTP 6-2-030, Beacon Devices, Electronic
- M. MTP 6-2-060, Data Processing Equipment
- N. MTP 6-2-070, Direction Finder Set, Radio
- O. MTP 6-2-182, Meteorological Equipment, Balloons
- P. MTP 6-2-184, Meteorological Equipment, Inflation, Tethering, and Launching Equipment
- Q. MTP 6-2-242, Receivers-Transmitters, General
- R. MTP 6-2-515, Transmitter Range Tests
- S. MTP 6-2-517, Frequency Accuracy and Stability

5. SCOPE

5.1 SUMMARY

5.1.1 Technical Characteristics

The test procedure describes the tests required to determine and evaluate the technical characteristics and technical performance of meteorological sounding systems.

The specific commodity subtests to be performed are listed below:

- a. Radiosonde Power Output - The objective of this subtest is to determine the power output of the radiosonde transmitter.
- b. Radiosonde Battery Life - The objective of this subtest is to determine the life of the batteries used in the radiosonde test item.
- c. Radiosonde Transmitter Range Test - The objective of this subtest is to determine the radiosonde's transmitter range.
- d. Sensor Response and Temperature, Humidity and Pressure Measuring Accuracy - The objective of this subtest is to determine the sensor response and the accuracy with which the radiosonde measures temperature, pressure and

humidity.

e. Upper Wind Speed and Direction Measuring Accuracy - The objective of this subtest is to determine the accuracy with which the system measures upper wind speed and direction.

f. Frequency Accuracy and Stability - The objective of this subtest is to determine the frequency stability and accuracy of the radiosonde transmitter and ground equipment.

g. Receiver Sensitivity - The objective of this subtest is to determine the sensitivity of the receiver by measuring the power level of the Minimum Discernible Signal (MDS).

h. Receiver Selectivity - The objective of this subtest is to determine the frequency response curve of the receiver.

i. Recording Equipment Test - The objective of this subtest is to determine the characteristics of the system's recorder (if applicable).

j. Computer Test - The objective of this subtest is to determine the characteristics and performance of the test item's computer system.

k. Antenna Test - The objective of this subtest is to determine the technical performance of the test item's antenna. (Ref. MTP 6-2-020).

l. Balloon Test - The objective of this subtest is to determine the technical performance of the balloon. (Ref. MTP 6-2-182).

m. Systems Test - The objective of this subtest is to determine the overall characteristics of the test item.

5.1.2 Common Engineering Tests

The following Common Engineering Tests, applicable to these commodities, are not included in this MTP:

- a. 6-2-500, Physical Characteristics
- b. 6-2-502, Human Factors Engineering
- c. 6-2-503, Reliability
- d. 6-2-504, Design for Maintainability
- e. 6-2-530, Altitude and Temperature-Altitude Tests
- f. 6-2-531, Temperature Tests
- g. 6-2-532, Sunshine Tests
- h. 6-2-533, Rain Tests
- i. 6-2-534, Humidity Tests
- j. 6-2-536, Salt Fog Tests
- k. 6-2-537, Dust Tests
- l. 6-2-539, Immersion Tests
- m. 6-2-540, Vibration Tests
- n. 6-2-541, Shock Tests

5.2 LIMITATIONS

The test procedures contained herein apply only to meteorological sounding systems which determine atmospheric pressure, temperature, humidity and upper atmospheric wind speed and direction. Testing of rocket carrier vehicles is not included.

6. PROCEDURES

6.1 PREPARATION FOR TEST

a. Select test equipment ideally having an accuracy of at least ten orders of magnitude greater than that afforded by the item under test, that is in keeping with the state of the art, and with calibrations traceable to the National Bureau of Standards.

b. Record the following information:

- 1) Nomenclature, serial number(s), manufacturer's name and function of the item(s) under test.
- 2) Nomenclature, serial number, accuracy tolerances, calibration requirements, and last date calibrated of the test equipment selected for the tests.

c. Ensure that all test personnel are familiar with the required technical and operational characteristics of the item under test, such as stipulated in Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR), and Technical Characteristics (TC).

d. Review all instructional material issued with the test item by the manufacturer, contractor, or government, as well as reports of previous similar tests conducted on the same types of equipment. These documents shall be kept readily available for reference.

e. Prepare record forms for systematic entry of data, chronology of test, and analysis in final evaluation of the test item.

f. Prepare adequate safety precautions to provide safety for personnel and equipment, and ensure that all safety SOP's are observed throughout the test.

g. Thoroughly inspect the test item for obvious physical and electrical defects such as cracked or broken parts, loose connections, bare or broken wires, loose assemblies, bent fragile parts, and corroded plugs and jacks. All defects shall be noted and corrected before proceeding with the test.

h. Prior to beginning any subtest, verify that the equipment is aligned, if necessary, as specified in the pertinent operating instructions to ensure, insofar as possible, it represents an average equipment in normal operating condition.

i. Prepare a test item sample plan sufficient to ensure that enough samples of all measurements are taken to provide statistical confidence of final data in accordance with MTP-3-1-002. Provisions shall be made for modification during test progress as may be indicated by monitored test results.

j. Ensure that appropriate security measures are instituted to safeguard classified materiel and data, as applicable, and that arrangements for supporting and participating agencies, activities, and facilities have been made.

6.2 TEST CONDUCT

NOTE: Modification of these procedures shall be made as required by technical design of the item under test and availability of test equipment, but only to the extent that such modifications

will not affect the validity of the test results.

6.2.1 Radiosonde Power Output Test

NOTE: The power output of the radiosonde transmitter is a good indication of its overall conditions and therefore shall be determined to a high degree of accuracy.

a. Connect the Radiosonde test item and the test instrumentation as shown in Figure 1.

b. Turn on the Radiosonde and instrumentation and allow sufficient time for all items to warm up and stabilize. (Reference the appropriate technical manuals).

c. Tune the Radiosonde transmitter to a standard test frequency, in accordance with the tuning procedure outlined in the appropriate technical manual. The degree of coupling afforded by the signal sampler shall be such that the input to the Noise and Field Intensity Meter (NFIM) is limited to a few volts.

NOTE: 1. This is not a test of the absolute power value as coupling losses are considered.

2. Since all emissions emanating from a transmitter are related to the fundamental output power, and since the fundamental output power can be expected to vary over the entire transmitter operating range, the power output tests shall cover the tuning range of the radiosonde transmitter.

d. Tune the NFIM to the Radiosonde's carrier frequency.

e. Note and record all indicator settings and attenuation factors used.

f. Substitute a signal from a signal generator tuned to the transmitter carrier frequency at the input to the NFIM. Adjust the output attenuator of the signal generator until the reference reading is again obtained on the NFIM.

g. Repeat the procedure of step e, above.

NOTE: The effects of decreasing battery voltage shall be determined in conjunction with the battery life test, paragraph 6.2.2.

h. Conduct other transmitter performance tests, as applicable, in accordance with MTP 6-2-242, (Receiver-Transmitter, General).

6.2.2 Radiosonde Battery Life Test

NOTE: The radiosonde battery life shall be determined in conjunction with temperature-altitude environmental chamber sensor tests.

a. Select three batteries at random and install them in a Radiosonde test item that has been packaged for normal flight.

b. Set the chamber temperature and altitude to simulate a ten minute

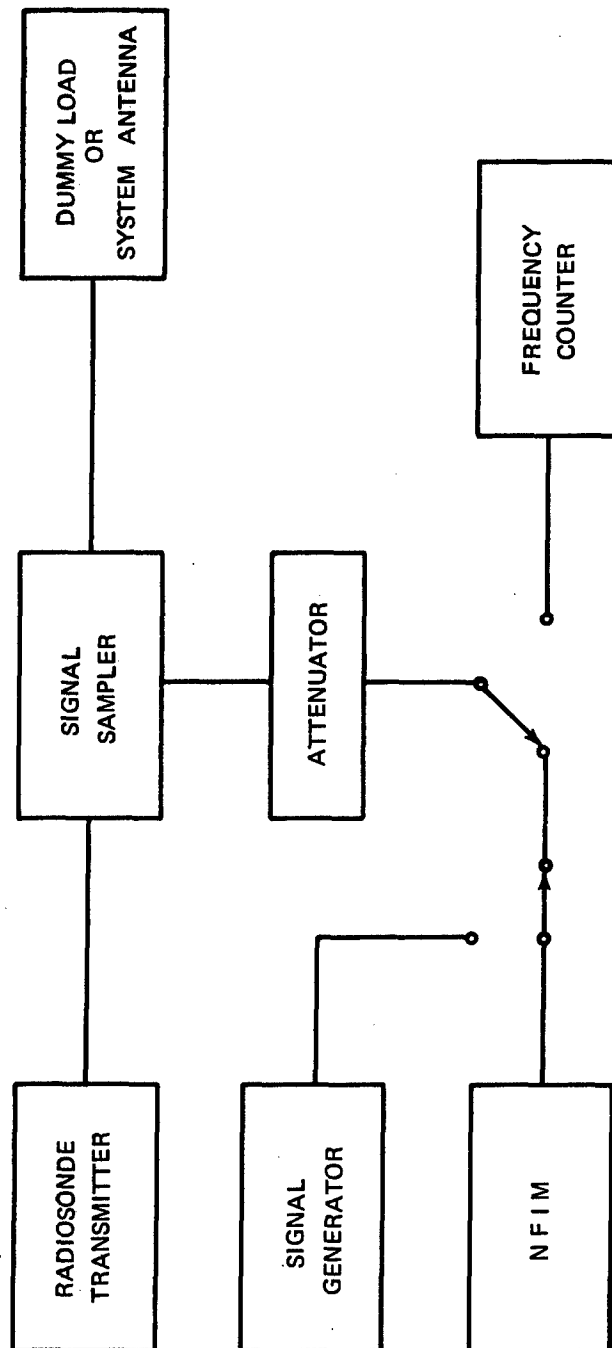


Figure 1. Radiosonde Power Output Measurement Block Diagram

check at ambient conditions. Then simulate a one hour flight to 100,000 feet.
c. Note and record battery voltage readings at 5-minute intervals during step b, above, including the return cycle from 100,000 feet to ambient conditions.

d. Note and record the lowest voltage level for a usable signal.

6.2.3 Radiosonde Transmitter Range Test

The Radiosonde transmitter range first shall be performed in accordance with MTP 6-2-515.

6.2.4 Sensor Response and Temperature, Humidity, and Pressure Accuracy Test

6.2.4.1 General

a. Conduct these tests under controlled conditions by comparison with calibrated laboratory standards (reference sensors).

b. Use pressure, temperature and humidity chambers that provide a range sufficient to cover the stated capability of the sounding element.

c. Use a fan to provide circulation of air for temperature and humidity tests.

d. Connect the Radiosonde output (by coax cable) to the receive-record unit.

NOTE: Since the transmitted value of the sensor "reading" depends upon the resistance versus frequency transfer characteristics of the Radiosonde, the uniformity of Radiosondes shall be checked during the test. Three or more Radiosondes of the same type shall be used on each chamber test. If sufficient receiving and recording equipment is not available, arrangements shall be made to record values alternately.

e. Adjust the Radiosonde to transmit one element (temperature or humidity) continuously during temperature and humidity tests.

- NOTE: 1. Since the recorder is used in this test the data may need adjustment depending upon the results of tests conducted in paragraphs 6.2.9 and 6.2.10.
2. Usually each Radiosonde is calibrated in a small chamber prior to flight and a correction (if any) applied to all readings. However, for this test a preliminary correction value will not be determined. The correction can be determined from the data.

6.2.4.2 Temperature Sensor

a. Conduct this test under controlled temperature conditions (chamber) by comparison with a reference standard accurate to ± 0.1 degree C.

b. Mount the reference sensor beside the Radiosonde temperature element. A low mass thermocouple with a rapid response is preferred.

c. Vary the chamber temperature in 5°C increments over the entire stated range of Radiosonde, from ambient temperature through the low temperature range, to the high range and return to ambient. Comparison readings shall be made each minute.

d. Install a small electrical heating element so heated air will flow over the sensors. Several times during the chamber test, apply current to the heating element for short periods and observe the response of the sensors. This will give an indication of the lag or response time of the temperature element.

e. If the Radiosonde temperature elements are replaceable, the test will be repeated with other elements.

6.2.4.3 Humidity Sensor

a. Conduct this subtest under controlled temperature and relative humidity conditions (chamber) by comparison with a reference standard accurate to $\pm 1\%$.

b. Starting with dry air (approximate) and with the temperature held constant at the highest stated operating temperature range of the humidity element, increase the moisture content of the air in the chamber in increments of about 10% relative humidity to approximately 100%. Condensation should not occur on the element. Humidity changes should be made as rapidly as possible and comparative readings should be obtained as often as the standard sensor will permit.

c. Repeat the readings at the low- and mid-temperature ranges of the humidity element.

6.2.4.4 Pressure System

a. Place the radiosonde in an altitude chamber (low pressure) with a calibrated aneroid barometer.

b. Compare the two readings and adjust the radiosonde element, using the calibration chart provided.

c. Raise the pressure in the chamber to the highest range of the pressure element.

d. Decrease the pressure in the chamber in the increments indicated on the calibration chart and compare values with the standard unit.

e. Decrease the pressure to the lowest operating range of the element.

6.2.5 Upper Wind Speed and Direction Measurement Accuracy Test

NOTE: One of the primary reasons for upper air soundings is to obtain wind data, which is determined from space positioning of the radiosonde or the sounding element. The space positioning is accomplished by radar and by Direction Finding (DF) radio gear. This test shall include minimum range and elevation angle for lock-on, low angle reflections and azimuth angle accuracy. The DF system characteristics shall be determined in accordance with MTP 6-2-070.

a. Determine the minimum range for lock-on by placing the sounding element 100 feet from the receiver unit and moving towards it while transmitting. Observe the distance at which the receiver is locked on the Radiosonde signal.

b. Determine the minimum elevation angle for lock-on by raising and lowering the radiosonde on a pole while transmitting. The minimum elevation angle for lock-on of the receiver and radiosonde shall be determined by means of a theodolite placed as near the ground unit as possible.

c. Determine the low angle reflection by raising and lowering a radiosonde on a captive balloon at 15° intervals around the ground unit and at two or three different ranges from the ground unit. Since the critical reflection angles usually are below 15° above the horizon, the tests should cover this angle as far from the ground unit as possible. The effect of low angles shall be noted and the exact angle measured with a theodolite.

NOTE: This test should be conducted during calm wind conditions.

d. Determine the azimuth angle accuracy by comparing the Radiosonde's azimuth position as indicated by the ground unit with the theodolite's azimuth angle indication, when performing step c, above.

6.2.6 Frequency Accuracy and Stability

The frequency accuracy and stability test shall be performed in accordance with MTP 6-2-517, Frequency Accuracy and Stability, for the sounding element and ground equipment, as appropriate.

6.2.7 Receiver Sensitivity Test

a. Connect the receiver under test and the test instrumentation as shown in Figure 2. The test setup (Figure 2) shall be in a shielded room with the apparatus on a grounded metal bench top.

b. Terminate the receiver output in the specified load impedance, the value of which may be found in the technical manual for the equipment under test.

NOTE: The receiver sensitivity measurement yields an overall indication of the receiver's operating condition, alignment and tracking.

c. Tune the receiver and signal generator to a low frequency in the receiver's tuning range (low, medium and high test frequencies within the receiver's tuning range shall be selected in accordance with MIL-STD-449).

NOTE: The type of modulation shall be the same as provided in the Radiosonde which is used with the system under test.

d. Set the signal generator modulation to approximately 30%.

e. Adjust the generator output so that the distortion analyzer shows a response at the sensitivity test output level. Note the generator output level in dbm and the frequency.

f. Repeat the above procedure for each test frequency, including a

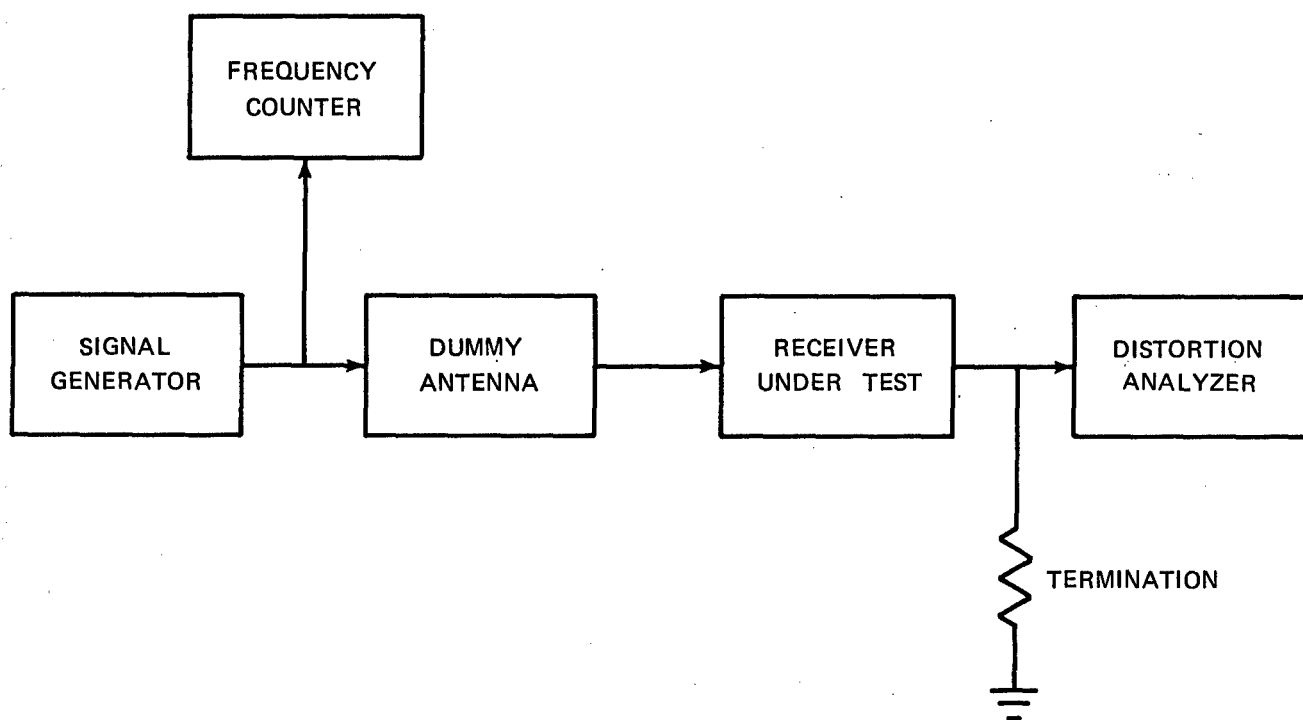


Figure 2. Sensitivity and Selectivity Measurement Block Diagram

specific measurement at the frequency of the sounding element used with the system.

6.2.8 Receiver Selectivity Test

a. Connect the receiver and test instrumentation in the same manner as described in paragraph 6.2.7 a (see Figure 2), with the addition of a frequency meter, which is coupled to the signal generator by means of a resistive pad or attenuator. Care must be taken to ensure that the frequency meter does not also couple into the receiver.

NOTE: The selectivity as measured by this test gives an indication of overall gain and sensitivity at the center tuned frequency. The test shows that the response at frequencies slightly removed from the tuned frequency is a measure of the receiver's ability to discriminate against off-channel radiations and in reality is also a measure of the receiver's bandpass characteristics.

- b. Perform a sensitivity test in accordance with paragraph 6.2.7.
- c. Increase the signal generator by 3 decibels.
- d. Tune the signal generator slowly below the receiver tuned frequency until the standard response is re-established.
- e. Note the signal generator input frequency and power output.
- f. Tune the signal generator slowly above the tuned frequency until the standard response is again re-established.
- g. Note the signal generator's input frequency and power output.
- h. Repeat the procedure for signal levels 6, 12, 20, 40, 60, and 80 decibels, above that established in step c, above.

6.2.9 Recording Equipment Test

- a. With the recording equipment connected in its normal operational configuration apply a known signal to the input of the recorder.
- b. Note and record the accuracy and sensitivity of the recorder.
- c. Repeat step a, above, applying at least 20 frequencies covering the range of the recorder.
- d. Repeat step b, above.

NOTE: The recording equipment may consist of a frequency meter and a paper chart recorder which can be run at various paper speeds. Each type of signal (temperature, humidity, and pressure) has a frequency (and sequence) depending upon the value of the measurement.

6.2.10 Computer Test

Complete testing shall be conducted in accordance with appropriate sections of MTP 6-2-060 and MTP 5-2-532.

NOTE: Some meteorological sounding systems use a computer to convert the received meteorological data to a more meaningful

interpretation of such data. The primary advantage in this type of system is the speed with which the data can be converted to meaningful interpretations and the straight readout of the pertinent data.

The computer portion of such a system shall be tested by means of a prerecorded tape containing the necessary data to be processed. The information on the test tape shall also be recorded on the visual recorder in order to provide a basis for analysis of test results. The computer must select values which have a pre-determined amount of change and other fixed values. These values can be manually measured on the visual chart and deviations between the input data and the output data determined and analyzed accordingly.

6.2.11 Antenna Test

Antenna tests shall be performed in accordance with MTP 6-2-020.

6.2.12 Balloon Test

Balloon tests shall be performed in accordance with MTP 6-2-182 and MTP 6-2-184.

6.2.13 System Test

- a. Select one or two relatively well known Radiosonde units from which the data received can be used as calibrated data.
- b. Mount the known Radiosonde units and the Radiosonde test item on a supporting structure as shown in Figure 3.

NOTE: Each Radiosonde unit shall transmit at a different frequency and the ground system shall be tuned to the specific frequency for the corresponding Radiosonde.

- c. Set up two theodolites at a known distance apart, one being as close to the ground unit as possible.
- d. Coordinate all operations involved, theodolite tracking, receiving ground unit, and balloon release personnel, and ensure that all data is time referenced to release of the balloon.
- e. Upon signal from the test director release the balloon assembly (see Figure 3) and commence tracking activities.

NOTE: The theodolites shall resolve the distance, azimuth and elevation angles during this test.

6.3 TEST DATA

6.3.1 Preparation for Test

Data to be recorded prior to testing shall include but not be limited

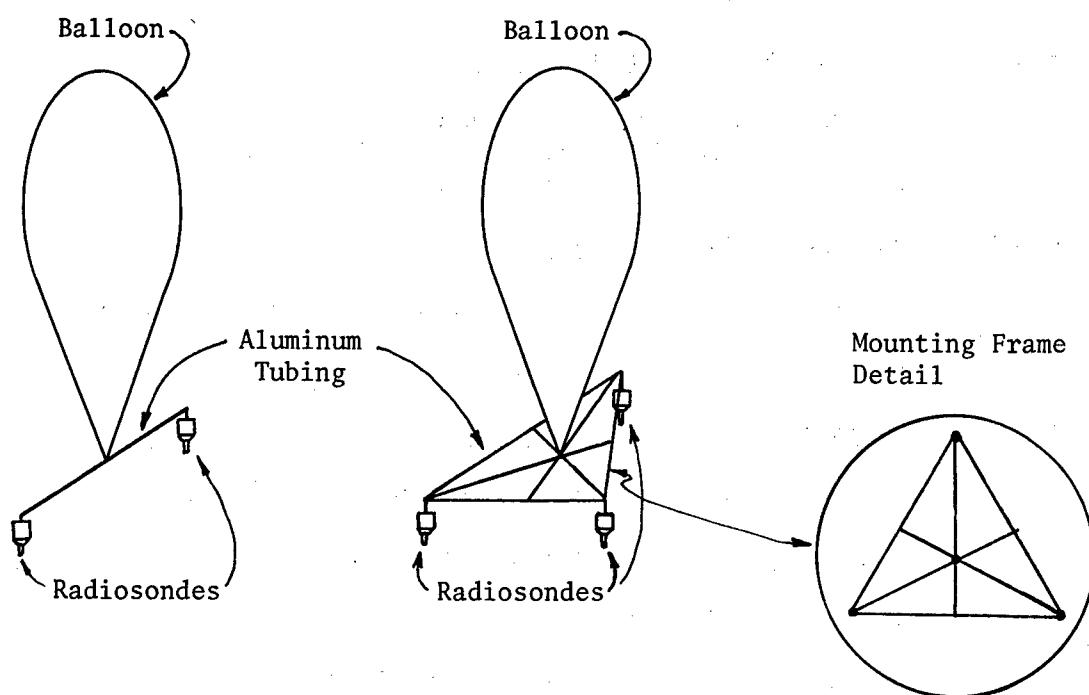


Figure 3. Mounting of Radiosonde for Systems Test.

to:

- a. Nomenclature, serial number(s), manufacturer's name, and function of the item(s) under test.
- b. Nomenclature, serial number, accuracy tolerances, calibration requirements, and last date calibrated of the test equipment selected for the tests.
- c. Damages to the test item incurred during transit and/or manufacturing defects.

6.3.2 Test Conduct

Data to be recorded in addition to specific instructions listed below for each subtest shall include:

6.3.3. Radiosonde Power Output Test

- a. Record Radiosonde's standard test frequency.
- b. Record signal generator output level and frequency.
- c. Record battery voltage at 5-minute intervals.

6.3.4 Radiosonde Battery Life Test

- a. Record battery voltage versus power output readings at 5-minute intervals.
- b. Record temperature-altitude values.

6.3.5 Radiosonde Transmitter Range Test

Data shall be recorded in accordance with MTP 6-2-515.

6.3.6 Sensor Response and Temperature, Humidity and Pressure Accuracy Test

6.3.6.1 Temperature Sensor

- a. Record reference sensor temperature and test item temperature indications at one minute intervals.
- b. Record lag or response time of temperature element relative to reference sensor.
- c. Record Radiosonde variations.

6.3.6.2 Humidity Sensor

- a. Record reference sensor humidity indication versus test item humidity indication as a function of time.
- b. Record temperature.
- c. Record Radiosonde variations.

6.3.6.3 Pressure System

- a. Record aneroid barometer indication together with test item

pressure indication over the range specified.

- b. Record Radiosonde variations.

6.3.7 Upper Atmospheric Wind Speed and Direction Measuring Accuracy Test

Data shall be recorded as specified in MTP 6-2-070, in addition to the following:

- a. The minimum distance for signal lock-on shall be recorded.
- b. The minimum elevation angle for signal lock-on shall be recorded.
- c. The azimuth and elevation angles and range for any meaningful signal effect shall be recorded.
- d. The azimuth angle readings from the ground unit and the angles measured with the theodolite shall be recorded.

6.3.8 Frequency Accuracy and Stability Test

Data shall be recorded in accordance with MTP 6-2-517.

6.3.9 Receiver Sensitivity Test

- a. Record the test frequency for each step.
- b. Record the generator output level in dbm.

6.3.10 Receiver Selectivity Test

Record signal generator's input frequency and power output at various signal levels.

6.3.11 Recording Equipment Test

- a. Record the frequency of the input signals.
- b. Record the recorded output data.

6.3.12 Computer Test

- a. Record data input.
- b. Record data output.
- c. Record other data as required by MTP's 6-2-060 and 5-2-532.

6.3.13 Antenna Test

The data shall be recorded as specified in MTP 6-2-020.

6.3.14 Balloon Test

The data shall be recorded in accordance with MTP 6-2-182 and MTP 6-2-184.

6.3.15 System Test

- a. Record the transmitting frequency of each Radiosonde.
- b. Record receiver data from each system.
- c. Record distance between theodolites.
- d. Record azimuth and elevation angles from each theodolite.

6.4 DATA REDUCTION AND PRESENTATION

Processing of raw test data shall, in general, consist of organizing, marking for correlation and identification, and grouping the test data according to subtest title. Test criteria or test item specifications shall be noted on the test data presentation to facilitate analysis and comparison. Where necessary, test data measurements shall be converted to be compatible with units given by test criteria or specifications.

6.4.1 Radiosonde Power Output Test

The data shall be presented in a suitable form for comparison with applicable criteria.

6.4.2 Radiosonde Battery Life Test

Present the data in a graphic form for comparison with applicable criteria.

6.4.3 Radiosonde Transmitter Range Test

The data shall be presented in accordance with MTP 6-2-515.

6.4.4 Sensor Response and Temperature, Humidity and Pressure Accuracy Test

The data shall be presented in a suitable form for comparison with applicable criteria.

6.4.5 Upper Atmospheric Wind Speed and Direction Measuring Accuracy Test

- a. The data shall be reduced and presented as specified in MTP 6-2-070.
- b. The data shall be presented in a suitable form for comparison with applicable criteria.

6.4.6 Frequency Accuracy and Stability

The data shall be presented in accordance with MTP 6-2-517.

6.4.7 Receiver Sensitivity Test

The data shall be presented in a suitable form for comparison with applicable criteria.

6.4.8 Receiver Selectivity Test

The data shall be presented in a suitable form for comparison with applicable criteria.

6.4.9 Recording Equipment Test

The sensitivity and accuracy data shall be presented in a suitable form for comparison with applicable criteria.

6.4.10 Computer Test

The data input and output shall be presented in a suitable form for comparison with applicable criteria.

6.4.11 Antenna Test

The data shall be reduced and presented as specified in MTP 6-2-020.

6.4.12 Balloon Test

The data shall be reduced and presented in accordance with MTP 6-2-182 and MTP 6-2-184.

6.4.13 System Test

The data shall be reduced and presented in a tabular form for comparison purposes.

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